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Bertness

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(54) **BATTERY MAINTENANCE TOOL WITH PROBE LIGHT**

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H01M 10/46 (2006.01)

(52) **U.S. Cl.** **320/114**

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See application file for complete search history.

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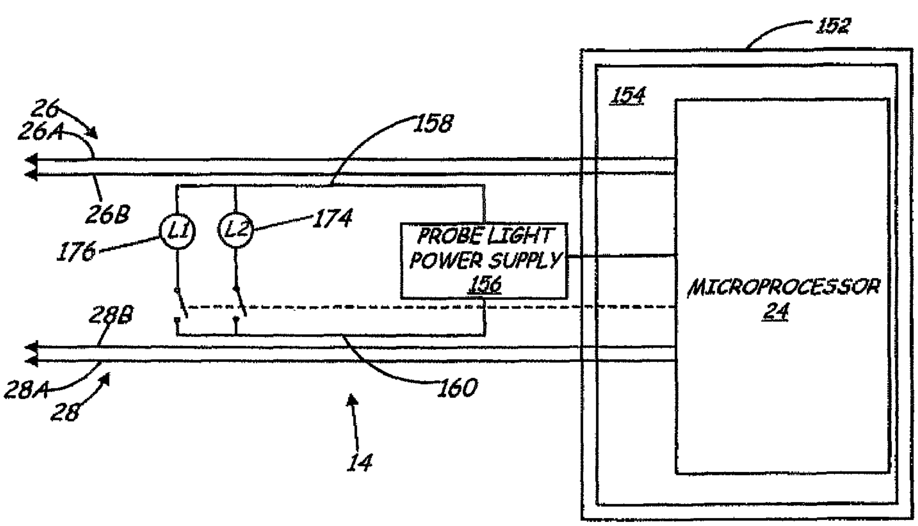
(57) **ABSTRACT**

A battery maintenance tool, which electrically couples to a battery, includes a maintenance tool housing and electronic circuitry within the maintenance tool housing. A cable, substantially external to the maintenance tool housing includes a plurality of conductors. At least some conductors of the plurality conductors are configured to electrically couple to the electronic circuitry within the maintenance tool housing. At least one probe light that is configured to electrically couple to at least two of the plurality of conductors in the cable is also included. The probe light, which is separate from the maintenance tool housing, receives power via the at least two of the plurality of conductors to which it is electrically coupled.

20 Claims, 9 Drawing Sheets



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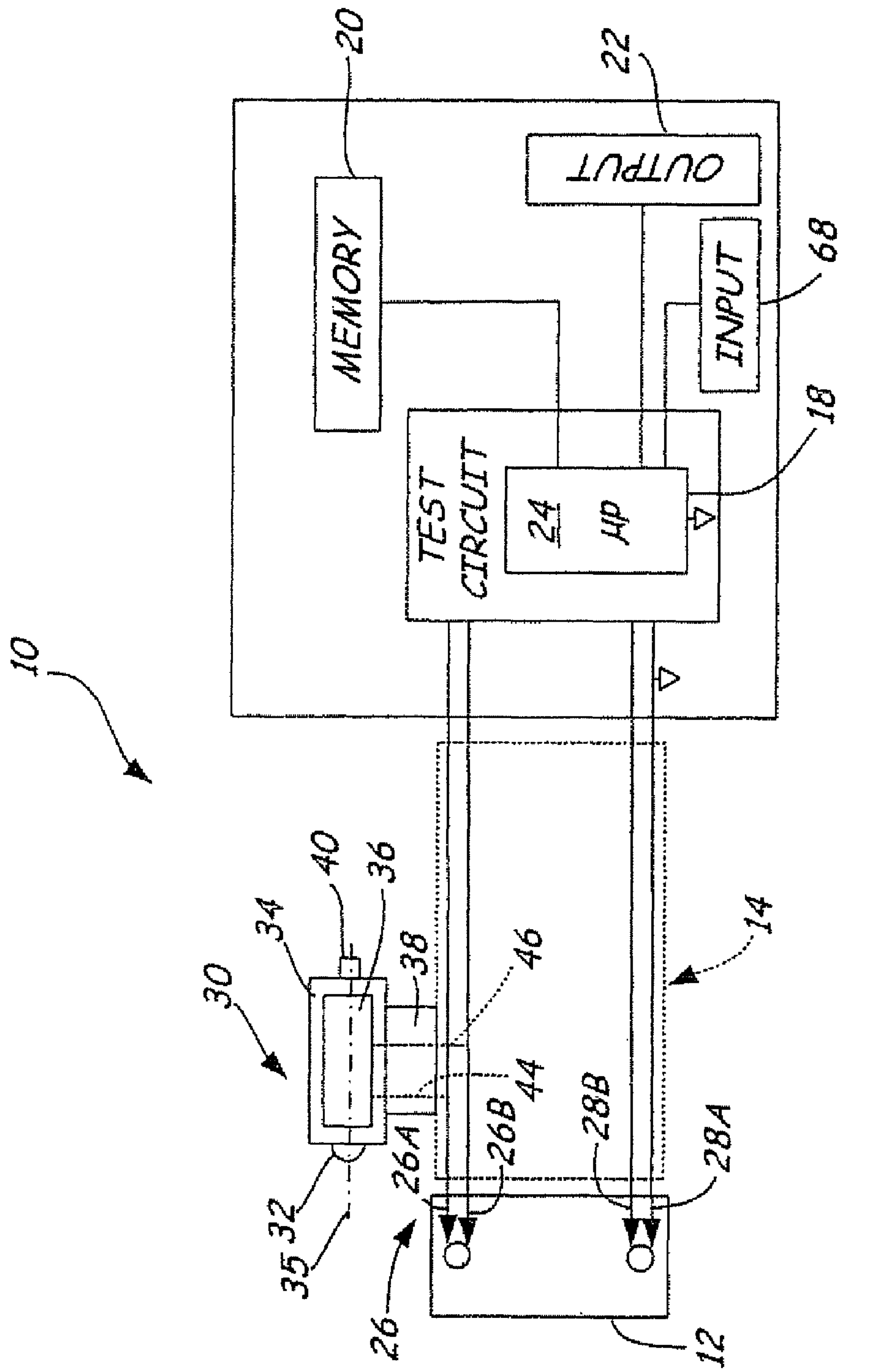
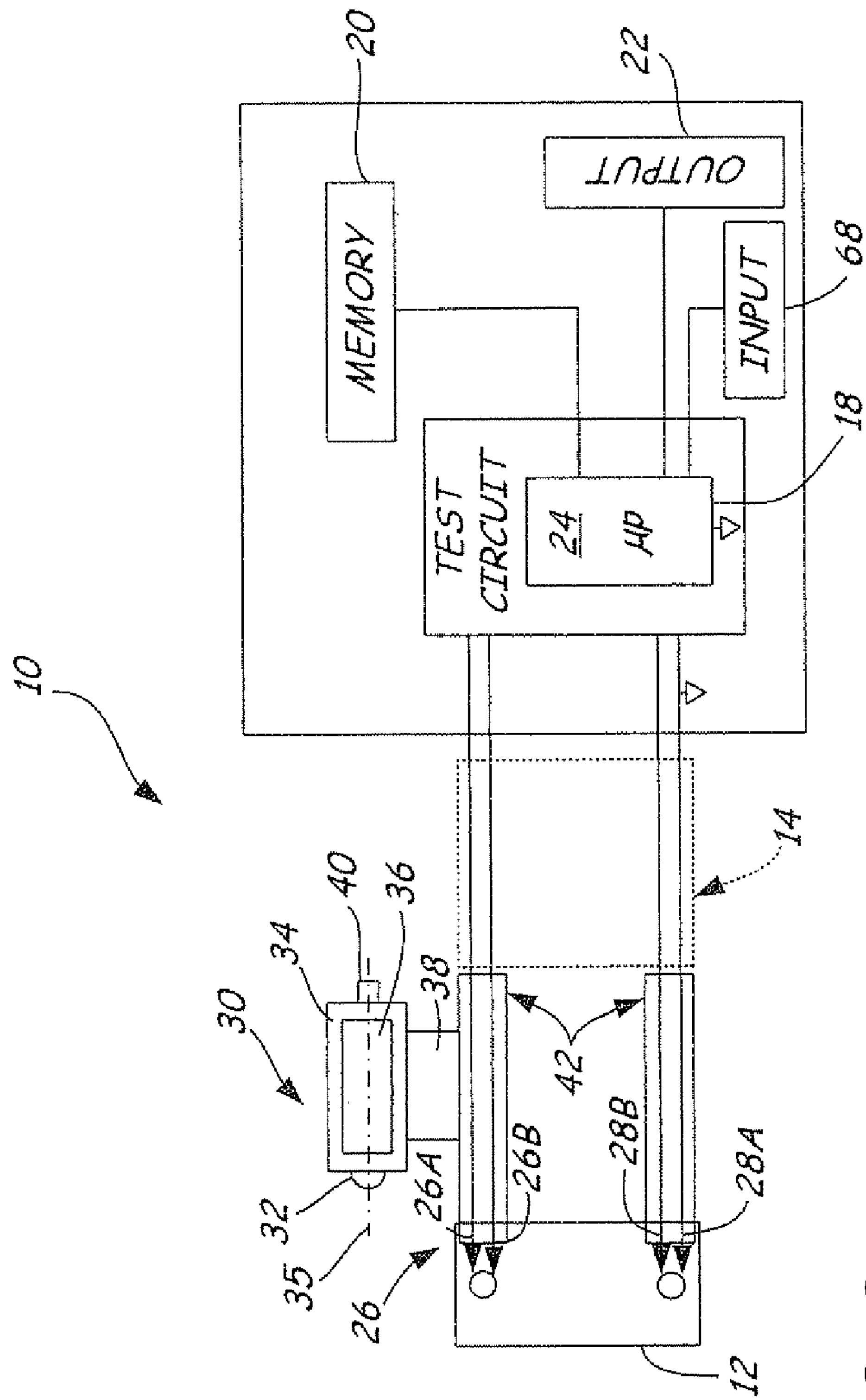


MEMORY
OUTPUT
INPUT
TEST CIRCUIT
24
μP
10
20
22
68
18
14
30
34
40
36
38
46
44
26A
26B
28B
28A
32
35
26
12

FIG. 1


10
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MEMORY
22
OUTPUT
INPUT
68
TEST CIRCUIT
24
μP
18
14
30
34
40
36
38
42
32
35
26A
26B
26
28B
28A
12

FIG. 2

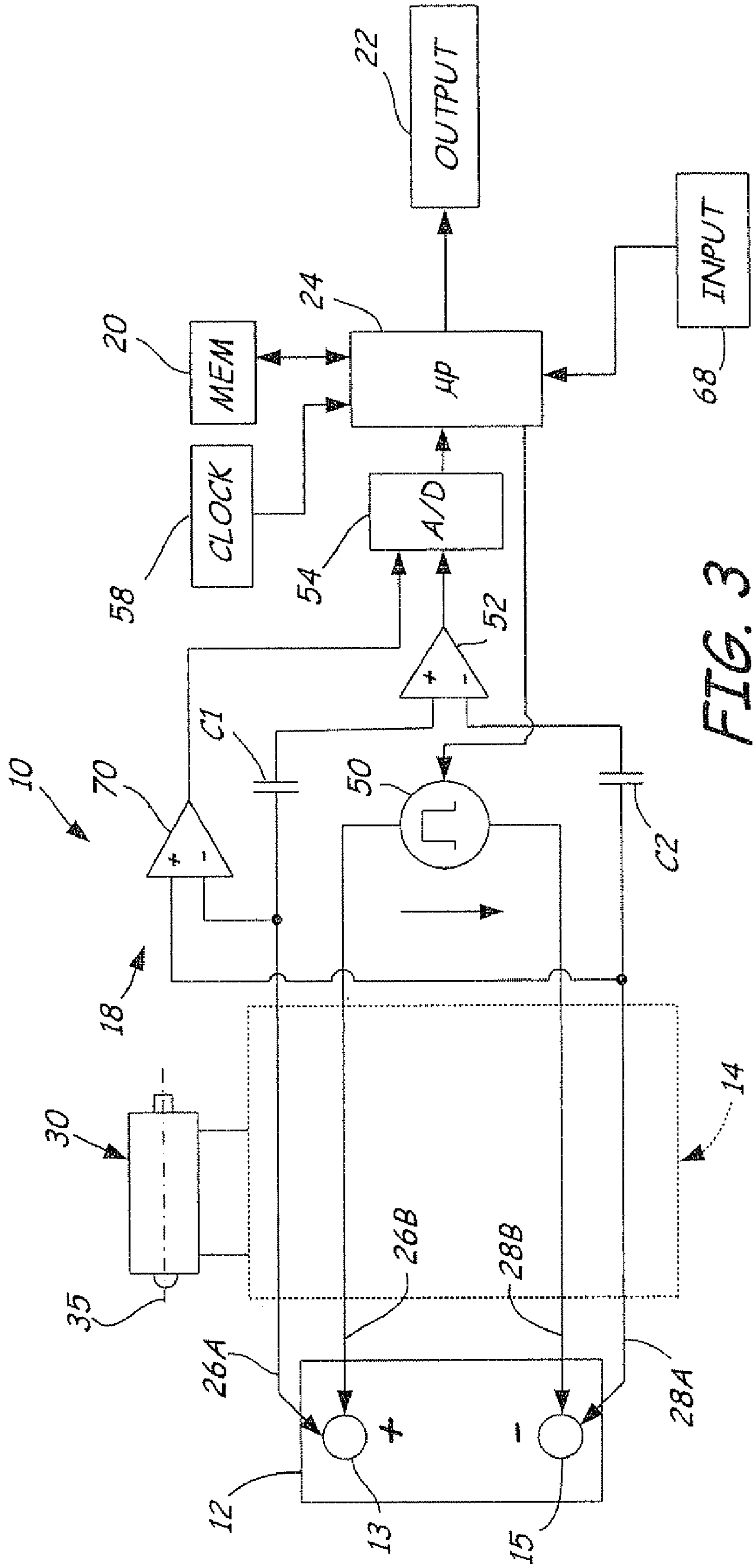
OUTPUT
22
INPUT
68
MEM
20
CLOCK
58
A/D
54
μp
24
10
70
C1
50
52
C2
18
30
14
35
26B
28B
26A
28A
12
13
15
+
-

FIG. 3

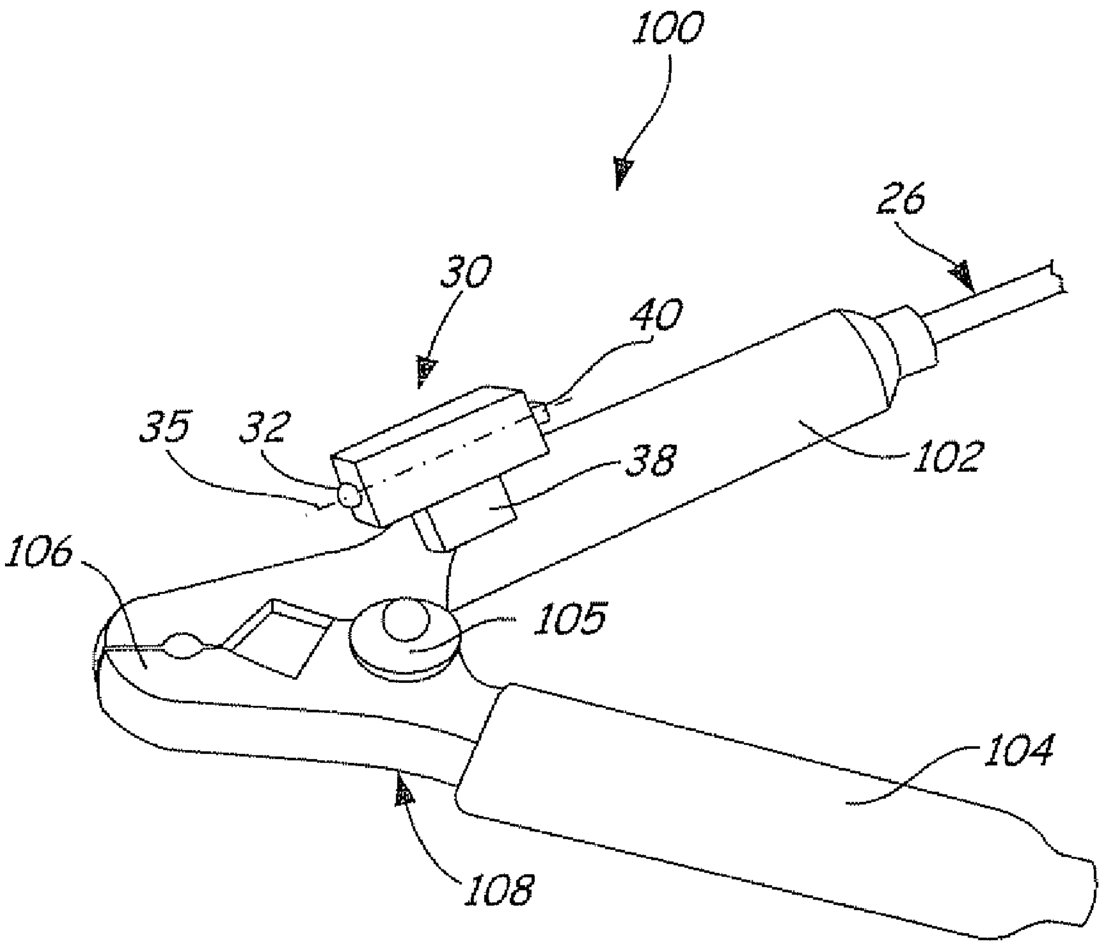

FIG. 4

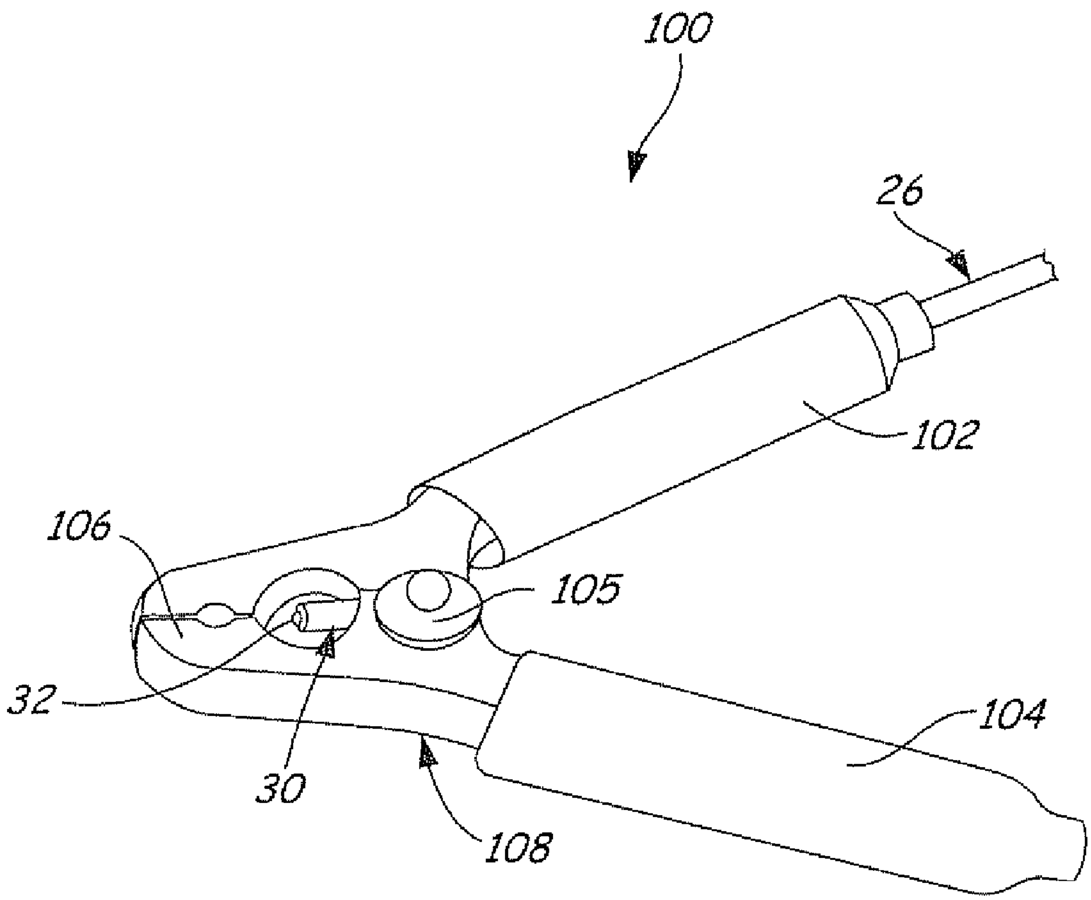

FIG. 5

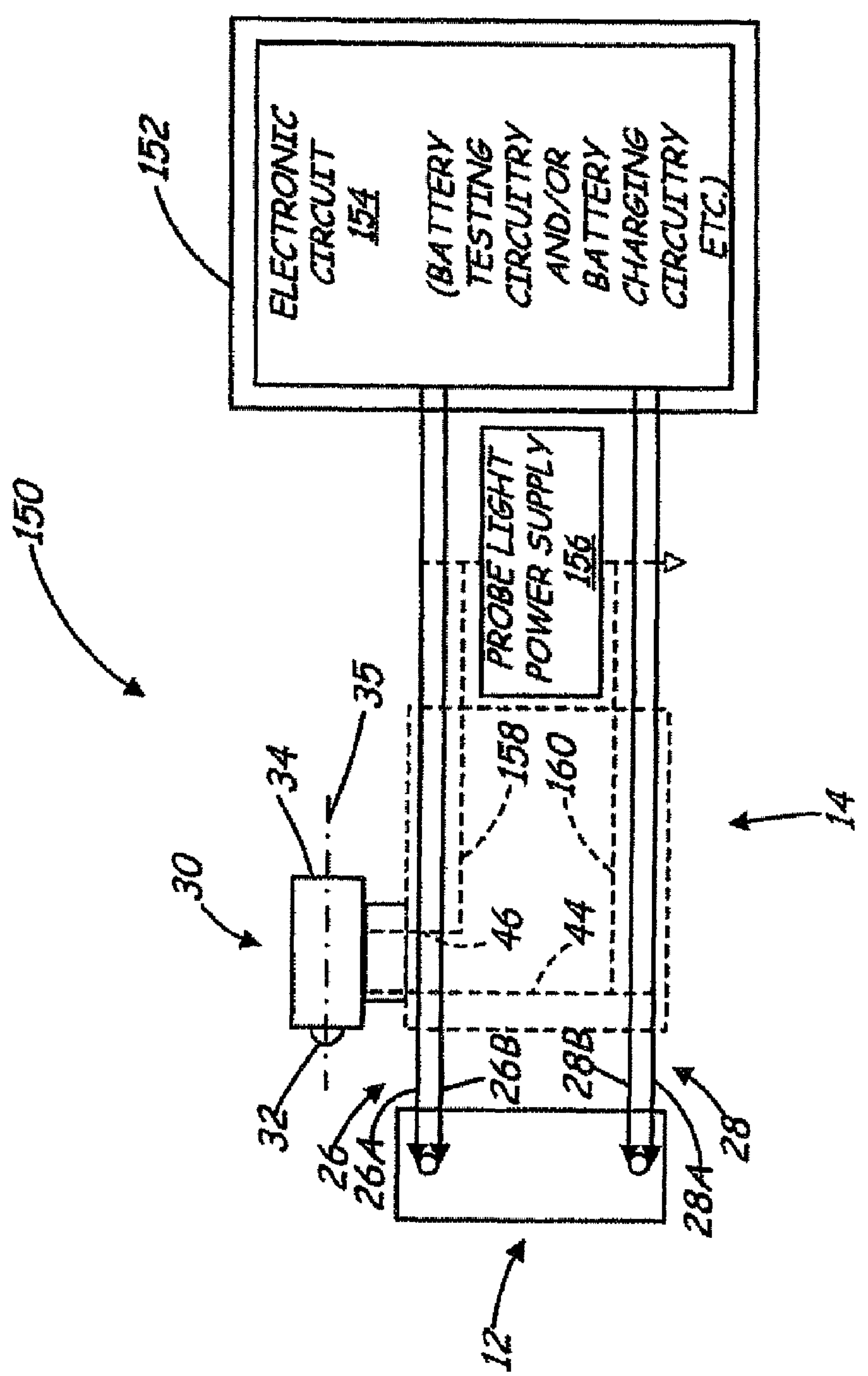
152
ELECTRONIC CIRCUIT 154
(BATTERY TESTING CIRCUITRY AND/OR BATTERY CHARGING CIRCUITRY ETC.)
150
PROBE LIGHT POWER SUPPLY 156
35
34
30
158
160
46
44
14
32
26B
28B
26
26A
28A
28
12

FIG. 6

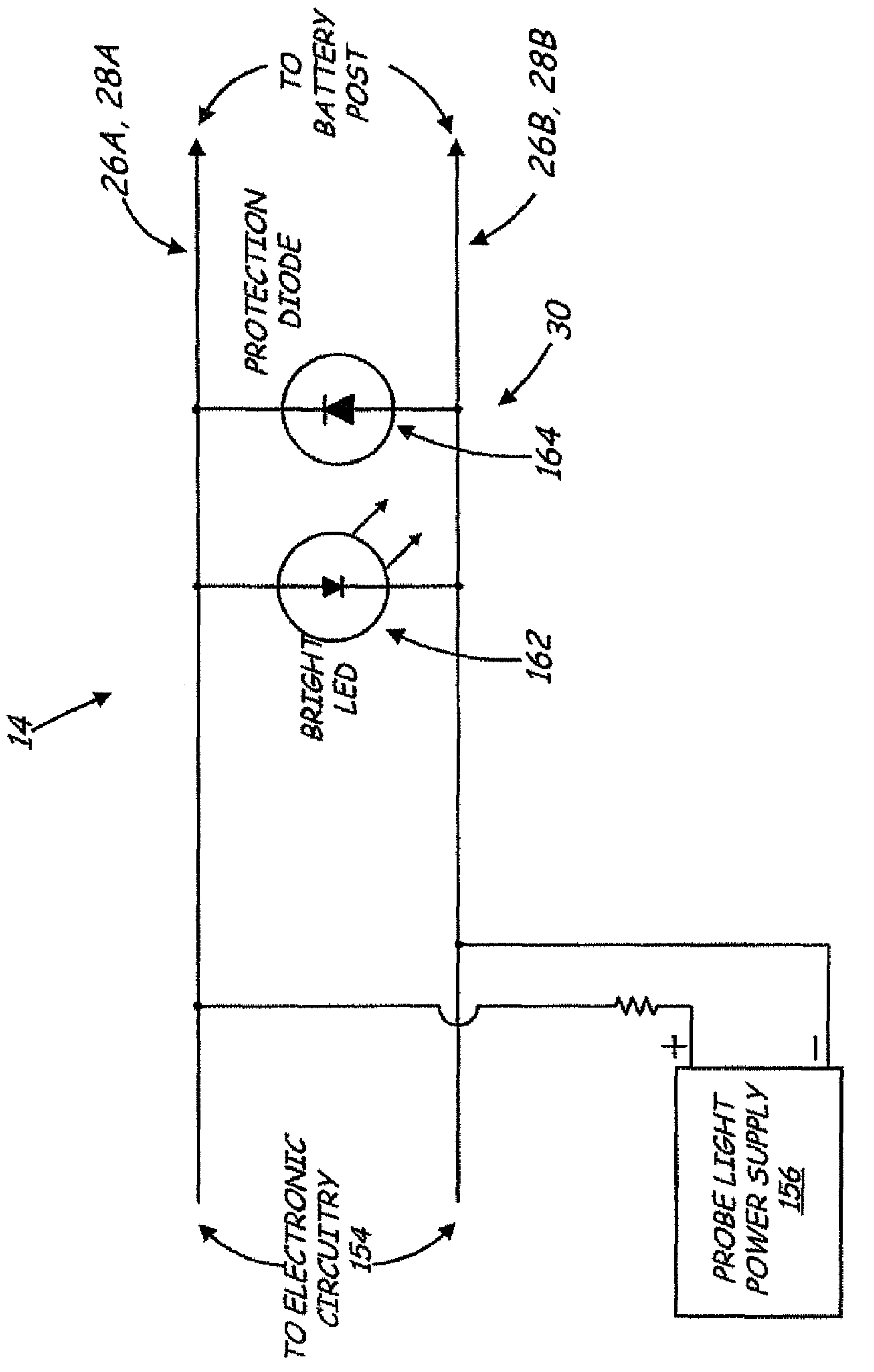
TO BATTERY POST
26A, 28A
26B, 28B
PROTECTION DIODE
30
164
BRIGHT LED
162
14
TO ELECTRONIC CIRCUITRY 154
PROBE LIGHT POWER SUPPLY 156
+
−

FIG. 7

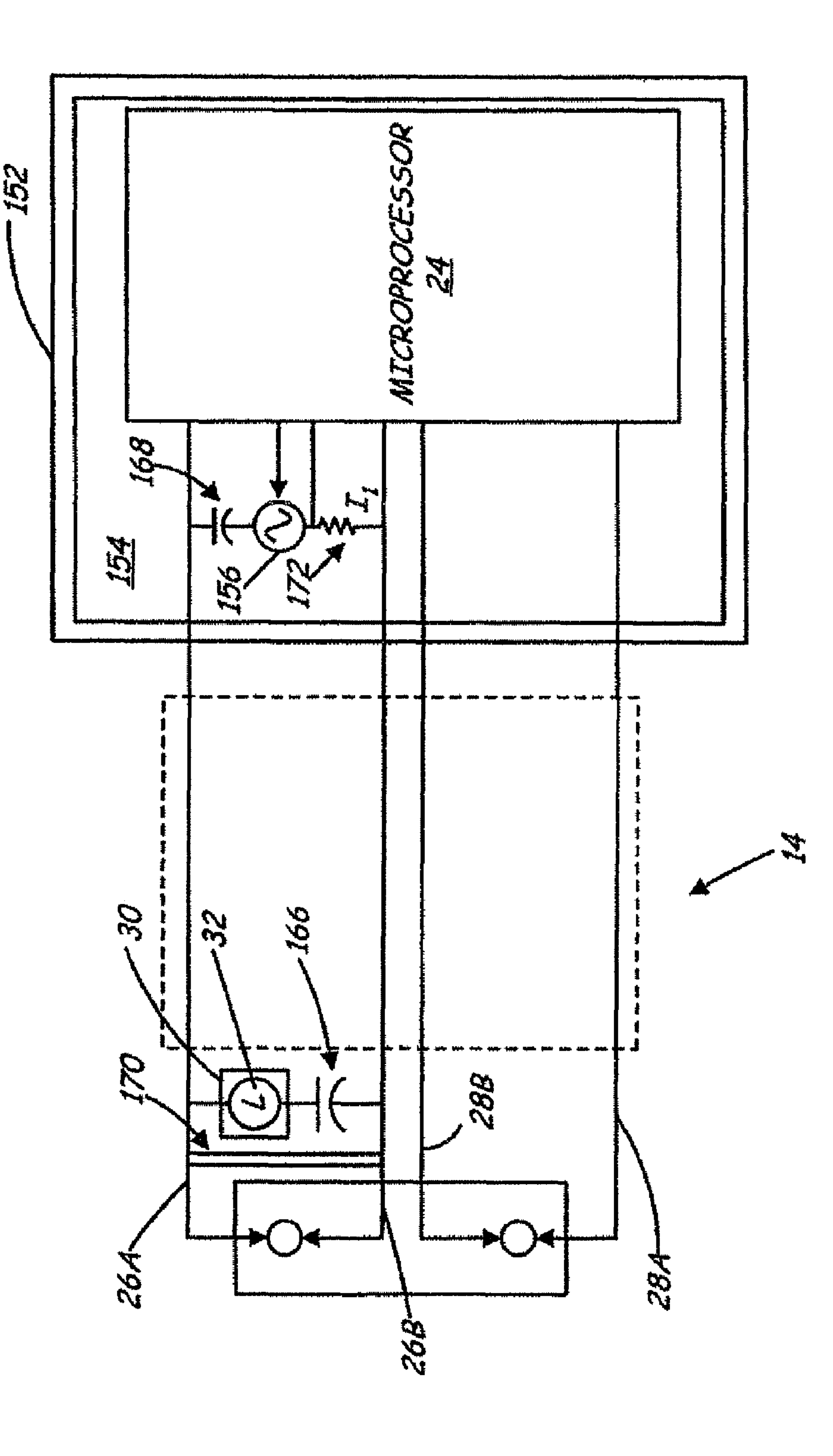
152
MICROPROCESSOR
24
154
168
156
172
I_1
14
30
32
166
170
28B
26A
26B
28A

FIG. 8

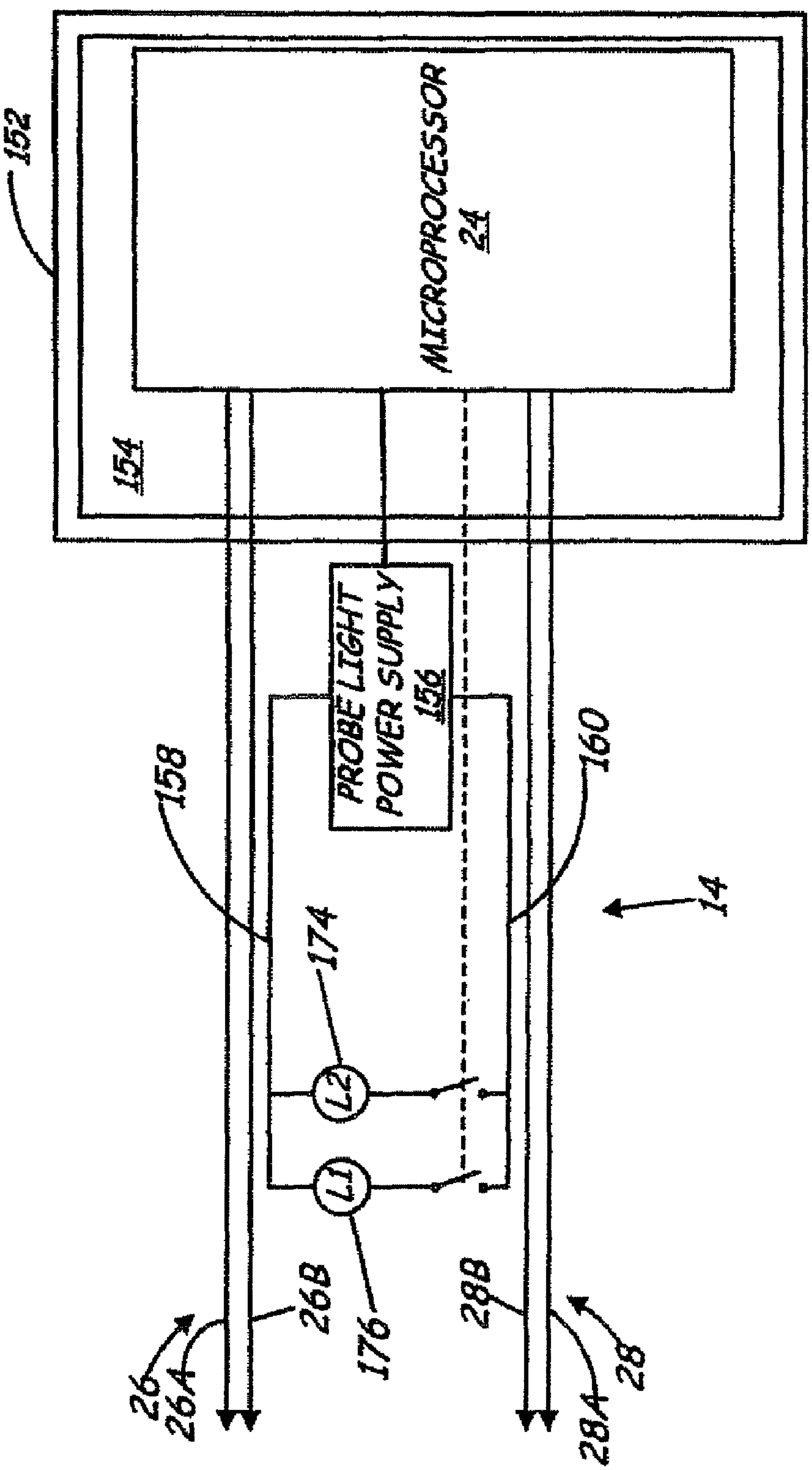
152
154
MICROPROCESSOR
24
PROBE LIGHT
POWER SUPPLY
156
158
160
14
174
L2
L1
176
26
26A
26B
28
28A
28B

FIG. 9

BATTERY MAINTENANCE TOOL WITH PROBE LIGHT

The present application is a continuation-in-part of U.S. patent application Ser. No. 10/681,666, filed Oct. 8, 2003, entitled "ELECTRONIC BATTERY TESTER WITH PROBE LIGHT," the contents of which are hereby incorporated by reference in their entirety.

BACKGROUND

The present embodiments relate to storage batteries. More specifically, the present embodiments relate to battery maintenance tools.

Storage batteries, such as lead acid storage batteries, are used in a variety of applications such as automotive vehicles and standby power sources. Typical storage batteries consist of a plurality of individual storage cells which are electrically connected in series. Each cell can have a voltage potential of about 2.1 volts, for example. By connecting the cells in the series, the voltages of the individual cells are added in a cumulative manner. For example, in a typical automotive storage battery, six storage cells are used to provide a total voltage of about 12.6 volts. The individual cells are held in a housing and the entire assembly is commonly referred to as the "battery."

It is frequently desirable to ascertain the condition of a storage battery. Various testing techniques have been developed over the long history of storage batteries. For example, one technique involves the use of a hygrometer in which the specific gravity of the acid mixture in the battery is measured. Electrical testing has also been used to provide less invasive battery testing techniques. A very simple electrical test is to simply measure the voltage across the battery. If the voltage is below a certain threshold, the battery is determined to be bad. Another technique for testing a battery is referred to as a load test. In a load test, the battery is discharged using a known load. As the battery is discharged, the voltage across the battery is monitored and used to determine the condition of the battery. More recently, techniques have been pioneered by Dr. Keith S. Champlin and Midtronics, Inc. of Willowbrook, Ill. for testing storage battery by measuring a dynamic parameter of the battery such as the dynamic conductance of the battery. These techniques are described in a number of United States patents, for example, U.S. Pat. No. 3,873,911, issued Mar. 25, 1975, to Champlin, entitled ELECTRONIC BATTERY TESTING DEVICE; U.S. Pat. No. 3,909,708, issued Sep. 30, 1975, to Champlin, entitled ELECTRONIC BATTERY TESTING DEVICE; U.S. Pat. No. 4,816,768, issued Mar. 28, 1989, to Champlin, entitled ELECTRONIC BATTERY TESTING DEVICE; U.S. Pat. No. 4,825,170, issued Apr. 25, 1989, to Champlin, entitled ELECTRONIC BATTERY TESTING DEVICE WITH AUTOMATIC VOLTAGE SCALING; U.S. Pat. No. 4,881,038, issued Nov. 14, 1989, to Champlin, entitled ELECTRONIC BATTERY TESTING DEVICE WITH AUTOMATIC VOLTAGE SCALING TO DETERMINE DYNAMIC CONDUCTANCE; U.S. Pat. No. 4,912,416, issued Mar. 27, 1990, to Champlin, entitled ELECTRONIC BATTERY TESTING DEVICE WITH STATE-OF-CHARGE COMPENSATION; U.S. Pat. No. 5,140,269, issued Aug. 18, 1992, to Champlin, entitled ELECTRONIC TESTER FOR ASSESSING BATTERY/CELL CAPACITY; U.S. Pat. No. 5,343,380, issued Aug. 30, 1994, entitled METHOD AND APPARATUS FOR SUPPRESSING TIME VARYING SIGNALS IN BATTERIES UNDERGOING CHARGING OR DISCHARGING; U.S. Pat. No. 5,572,136, issued Nov. 5, 1996, entitled ELEC-

TRONIC BATTERY TESTER WITH AUTOMATIC COMPENSATION FOR LOW STATE-OF-CHARGE; U.S. Pat. No. 5,574,355, issued Nov. 12, 1996, entitled METHOD AND APPARATUS FOR DETECTION AND CONTROL OF THERMAL RUNAWAY IN A BATTERY UNDER CHARGE; U.S. Pat. No. 5,585,416, issued Dec. 10, 1996, entitled APPARATUS AND METHOD FOR STEP-CHARGING BATTERIES TO OPTIMIZE CHARGE ACCEPTANCE; U.S. Pat. No. 5,585,728, issued Dec. 17, 1996, entitled ELECTRONIC BATTERY TESTER WITH AUTOMATIC COMPENSATION FOR LOW STATE-OF-CHARGE; U.S. Pat. No. 5,589,757, issued Dec. 31, 1996, entitled APPARATUS AND METHOD FOR STEP-CHARGING BATTERIES TO OPTIMIZE CHARGE ACCEPTANCE; U.S. Pat. No. 5,592,093, issued Jan. 7, 1997, entitled ELECTRONIC BATTERY TESTING DEVICE LOOSE TERMINAL CONNECTION DETECTION VIA A COMPARISON CIRCUIT; U.S. Pat. No. 5,598,098, issued Jan. 28, 1997, entitled ELECTRONIC BATTERY TESTER WITH VERY HIGH NOISE IMMUNITY; U.S. Pat. No. 5,656,920, issued Aug. 12, 1997, entitled METHOD FOR OPTIMIZING THE CHARGING LEAD-ACID BATTERIES AND AN INTERACTIVE CHARGER; U.S. Pat. No. 5,757,192, issued May 26, 1998, entitled METHOD AND APPARATUS FOR DETECTING A BAD CELL IN A STORAGE BATTERY; U.S. Pat. No. 5,821,756, issued Oct. 13, 1998, entitled ELECTRONIC BATTERY TESTER WITH TAILORED COMPENSATION FOR LOW STATE-OF-CHARGE; U.S. Pat. No. 5,831,435, issued Nov. 3, 1998, entitled BATTERY TESTER FOR JIS STANDARD; U.S. Pat. No. 5,914,605, issued Jun. 22, 1999, entitled ELECTRONIC BATTERY TESTER; U.S. Pat. No. 5,945,829, issued Aug. 31, 1999, entitled MIDPOINT BATTERY MONITORING; U.S. Pat. No. 6,002,238, issued Dec. 14, 1999, entitled METHOD AND APPARATUS FOR MEASURING COMPLEX IMPEDANCE OF CELLS AND BATTERIES; U.S. Pat. No. 6,037,751, issued Mar. 14, 2000, entitled APPARATUS FOR CHARGING BATTERIES; U.S. Pat. No. 6,037,777, issued Mar. 14, 2000, entitled METHOD AND APPARATUS FOR DETERMINING BATTERY PROPERTIES FROM COMPLEX IMPEDANCE/ADMITTANCE; U.S. Pat. No. 6,051,976, issued Apr. 18, 2000, entitled METHOD AND APPARATUS FOR AUDITING A BATTERY TEST; U.S. Pat. No. 6,081,098, issued Jun. 27, 2000, entitled METHOD AND APPARATUS FOR CHARGING A BATTERY; U.S. Pat. No. 6,091,245, issued Jul. 18, 2000, entitled METHOD AND APPARATUS FOR AUDITING A BATTERY TEST; U.S. Pat. No. 6,104,167, issued Aug. 15, 2000, entitled METHOD AND APPARATUS FOR CHARGING A BATTERY; U.S. Pat. No. 6,137,269, issued Oct. 24, 2000, entitled METHOD AND APPARATUS FOR ELECTRONICALLY EVALUATING THE INTERNAL TEMPERATURE OF AN ELECTROCHEMICAL CELL OR BATTERY; U.S. Pat. No. 6,163,156, issued Dec. 19, 2000, entitled ELECTRICAL CONNECTION FOR ELECTRONIC BATTERY TESTER; U.S. Pat. No. 6,172,483, issued Jan. 9, 2001, entitled METHOD AND APPARATUS FOR MEASURING COMPLEX IMPEDANCE OF CELL AND BATTERIES; U.S. Pat. No. 6,172,505, issued Jan. 9, 2001, entitled ELECTRONIC BATTERY TESTER; U.S. Pat. No. 6,222,369, issued Apr. 24, 2001, entitled METHOD AND APPARATUS FOR DETERMINING BATTERY PROPERTIES FROM COMPLEX IMPEDANCE/ADMITTANCE; U.S. Pat. No. 6,225,808, issued May 1, 2001, entitled TEST COUNTER FOR ELECTRONIC BATTERY TESTER; U.S. Pat. No. 6,249,124, issued Jun. 19, 2001, entitled ELECTRONIC BATTERY TESTER WITH INTER-

NAL BATTERY; U.S. Pat. No. 6,259,254, issued Jul. 10, 2001, entitled APPARATUS AND METHOD FOR CARRYING OUT DIAGNOSTIC TESTS ON BATTERIES AND FOR RAPIDLY CHARGING BATTERIES; U.S. Pat. No. 6,262,563, issued Jul. 17, 2001, entitled METHOD AND APPARATUS FOR MEASURING COMPLEX ADMITTANCE OF CELLS AND BATTERIES; U.S. Pat. No. 6,294,896, issued Sep. 25, 2001; entitled METHOD AND APPARATUS FOR MEASURING COMPLEX SELF-IMMITANCE OF A GENERAL ELECTRICAL ELEMENT; U.S. Pat. No. 6,294,897, issued Sep. 25, 2001, entitled METHOD AND APPARATUS FOR ELECTRONICALLY EVALUATING THE INTERNAL TEMPERATURE OF AN ELECTROCHEMICAL CELL OR BATTERY; U.S. Pat. No. 6,304,087, issued Oct. 16, 2001, entitled APPARATUS FOR CALIBRATING ELECTRONIC BATTERY TESTER; U.S. Pat. No. 6,310,481, issued Oct. 30, 2001, entitled ELECTRONIC BATTERY TESTER; U.S. Pat. No. 6,313,607, issued Nov. 6, 2001, entitled METHOD AND APPARATUS FOR EVALUATING STORED CHARGE IN AN ELECTROCHEMICAL CELL OR BATTERY; U.S. Pat. No. 6,313,608, issued Nov. 6, 2001, entitled METHOD AND APPARATUS FOR CHARGING A BATTERY; U.S. Pat. No. 6,316,914, issued Nov. 13, 2001, entitled TESTING PARALLEL STRINGS OF STORAGE BATTERIES; U.S. Pat. No. 6,323,650, issued Nov. 27, 2001, entitled ELECTRONIC BATTERY TESTER; U.S. Pat. No. 6,329,793, issued Dec. 11, 2001, entitled METHOD AND APPARATUS FOR CHARGING A BATTERY; U.S. Pat. No. 6,331,762, issued Dec. 18, 2001, entitled ENERGY MANAGEMENT SYSTEM FOR AUTOMOTIVE VEHICLE; U.S. Pat. No. 6,332,113, issued Dec. 18, 2001, entitled ELECTRONIC BATTERY TESTER; U.S. Pat. No. 6,351,102, issued Feb. 26, 2002, entitled AUTOMOTIVE BATTERY CHARGING SYSTEM TESTER; U.S. Pat. No. 6,359,441, issued Mar. 19, 2002, entitled ELECTRONIC BATTERY TESTER; U.S. Pat. No. 6,363,303, issued Mar. 26, 2002, entitled ALTERNATOR DIAGNOSTIC SYSTEM, U.S. Pat. No. 6,392,414, issued May 21, 2002, entitled ELECTRONIC BATTERY TESTER; U.S. Pat. No. 6,417,669, issued Jul. 9, 2002, entitled SUPPRESSING INTERFERENCE IN AC MEASUREMENTS OF CELLS, BATTERIES AND OTHER ELECTRICAL ELEMENTS; U.S. Pat. No. 6,424,158, issued Jul. 23, 2002, entitled APPARATUS AND METHOD FOR CARRYING OUT DIAGNOSTIC TESTS ON BATTERIES AND FOR RAPIDLY CHARGING BATTERIES; U.S. Pat. No. 6,441,585, issued Aug. 17, 2002, entitled APPARATUS AND METHOD FOR TESTING RECHARGEABLE ENERGY STORAGE BATTERIES; U.S. Pat. No. 6,445,158, issued Sep. 3, 2002, entitled VEHICLE ELECTRICAL SYSTEM TESTER WITH ENCODED OUTPUT; U.S. Pat. No. 6,456,045, issued Sep. 24, 2002, entitled INTEGRATED CONDUCTANCE AND LOAD TEST BASED ELECTRONIC BATTERY TESTER; U.S. Pat. No. 6,466,025, issued Oct. 15, 2002, entitled ALTERNATOR TESTER; U.S. Pat. No. 6,466,026, issued Oct. 15, 2002, entitled PROGRAMMABLE CURRENT EXCITER FOR MEASURING AC IMMITTANCE OF CELLS AND BATTERIES; U.S. Pat. No. 6,534,993, issued Mar. 18, 2003, entitled ELECTRONIC BATTERY TESTER; U.S. Pat. No. 6,544,078, issued Apr. 8, 2003, entitled BATTERY CLAMP WITH INTEGRATED CURRENT SENSOR; U.S. Pat. No. 6,556,019, issued Apr. 29, 2003, entitled ELECTRONIC BATTERY TESTER; U.S. Pat. No. 6,566,883, issued May 20, 2003, entitled ELECTRONIC BATTERY TESTER; U.S. Pat. No. 6,586,941, issued Jul. 1, 2003, entitled BATTERY TESTER WITH DATABUS; U.S. Pat. No. 6,597,150, issued Jul. 22, 2003, entitled METHOD OF DISTRIBUTING JUMP-START BOOSTER PACKS; U.S. Ser. No. 09/780,146, filed Feb. 9, 2001, entitled STORAGE BATTERY WITH INTEGRAL BATTERY TESTER; U.S. Ser. No. 09/756,638, filed Jan. 8, 2001, entitled METHOD AND APPARATUS FOR DETERMINING BATTERY PROPERTIES FROM COMPLEX IMPEDANCE/ADMITTANCE; U.S. Ser. No. 09/862,783, filed May 21, 2001, entitled METHOD AND APPARATUS FOR TESTING CELLS AND BATTERIES EMBEDDED IN SERIES/PARALLEL SYSTEMS; U.S. Ser. No. 09/960,117, filed Sep. 20, 2001, entitled IN-VEHICLE BATTERY MONITOR; U.S. Ser. No. 09/908,278, filed Jul. 18, 2001, entitled BATTERY CLAMP WITH EMBEDDED ENVIRONMENT SENSOR; U.S. Ser. No. 09/880,473, filed Jun. 13, 2001; entitled BATTERY TEST MODULE; U.S. Ser. No. 09/940,684, filed Aug. 27, 2001, entitled METHOD AND APPARATUS FOR EVALUATING STORED CHARGE IN AN ELECTROCHEMICAL CELL OR BATTERY; U.S. Ser. No. 60/330,441, filed Oct. 17, 2001, entitled ELECTRONIC BATTERY TESTER WITH RELATIVE TEST OUTPUT; U.S. Ser. No. 60/348,479, filed Oct. 29, 2001, entitled CONCEPT FOR TESTING HIGH POWER VRLA BATTERIES; U.S. Ser. No. 10/046,659, filed Oct. 29, 2001, entitled ENERGY MANAGEMENT SYSTEM FOR AUTOMOTIVE VEHICLE; U.S. Ser. No. 09/993,468, filed Nov. 14, 2001, entitled KELVIN CONNECTOR FOR A BATTERY POST; U.S. Ser. No. 09/992,350, filed Nov. 26, 2001, entitled ELECTRONIC BATTERY TESTER, U.S. Ser. No. 60/341,902, filed Dec. 19, 2001, entitled BATTERY TESTER MODULE; U.S. Ser. No. 10/042,451, filed Jan. 8, 2002, entitled BATTERY CHARGE CONTROL DEVICE, U.S. Ser. No. 10/073,378, filed Feb. 8, 2002, entitled METHOD AND APPARATUS USING A CIRCUIT MODEL TO EVALUATE CELL/BATTERY PARAMETERS; U.S. Ser. No. 10/093,853, filed Mar. 7, 2002, entitled ELECTRONIC BATTERY TESTER WITH NETWORK COMMUNICATION; U.S. Ser. No. 60/364,656, filed Mar. 14, 2002, entitled ELECTRONIC BATTERY TESTER WITH LOW TEMPERATURE RATING DETERMINATION; U.S. Ser. No. 10/098,741, filed Mar. 14, 2002, entitled METHOD AND APPARATUS FOR AUDITING A BATTERY TEST; U.S. Ser. No. 10/112,114, filed Mar. 28, 2002; U.S. Ser. No. 10/109,734, filed Mar. 28, 2002; U.S. Ser. No. 10/112,105, filed Mar. 28, 2002, entitled CHARGE CONTROL SYSTEM FOR A VEHICLE BATTERY; U.S. Ser. No. 10/112,998, filed Mar. 29, 2002, entitled BATTERY TESTER WITH BATTERY REPLACEMENT OUTPUT; U.S. Ser. No. 10/119,297, filed Apr. 9, 2002, entitled METHOD AND APPARATUS FOR TESTING CELLS AND BATTERIES EMBEDDED IN SERIES/PARALLEL SYSTEMS; U.S. Ser. No. 60/379,281, filed May 8, 2002, entitled METHOD FOR DETERMINING BATTERY STATE OF CHARGE; U.S. Ser. No. 60/387,046, filed Jun. 7, 2002, entitled METHOD AND APPARATUS FOR INCREASING THE LIFE OF A STORAGE BATTERY; U.S. Ser. No. 10/177,635, filed Jun. 21, 2002, entitled BATTERY CHARGER WITH BOOSTER PACK; U.S. Ser. No. 10/207,495, filed Jul. 29, 2002, entitled KELVIN CLAMP FOR ELECTRICALLY COUPLING TO A BATTERY CONTACT; U.S. Ser. No. 10/200,041, filed Jul. 19, 2002, entitled AUTOMOTIVE VEHICLE ELECTRICAL SYSTEM DIAGNOSTIC DEVICE; U.S. Ser. No. 10/217,913, filed Aug. 13, 2002, entitled, BATTERY TEST MODULE; U.S. Ser. No. 60/408,542, filed Sep. 5, 2002, entitled BATTERY TEST OUTPUTS ADJUSTED BASED UPON TEMPERATURE; U.S. Ser. No. 10/246,439, filed Sep. 18, 2002, entitled BATTERY TESTER UPGRADE USING SOFTWARE KEY; U.S. Ser.

No. 60/415,399, filed Oct. 2, 2002, entitled QUERY BASED ELECTRONIC BATTERY TESTER; and U.S. Ser. No. 10/263,473, filed Oct. 2, 2002, entitled ELECTRONIC BATTERY TESTER WITH RELATIVE TEST OUTPUT; U.S. Ser. No. 60/415,796, filed Oct. 3, 2002, entitled QUERY BASED ELECTRONIC BATTERY TESTER; U.S. Ser. No. 10/271,342, filed Oct. 15, 2002, entitled IN-VEHICLE BATTERY MONITOR; U.S. Ser. No. 10/270,777, filed Oct. 15, 2002, entitled PROGRAMMABLE CURRENT EXCITER FOR MEASURING AC IMMITTANCE OF CELLS AND BATTERIES; U.S. Ser. No. 10/310,515, filed Dec. 5, 2002, entitled BATTERY TEST MODULE; U.S. Ser. No. 10/310,490, filed Dec. 5, 2002, entitled ELECTRONIC BATTERY TESTER; U.S. Ser. No. 10/310,385, filed Dec. 5, 2002, entitled BATTERY TEST MODULE, U.S. Ser. No. 60/437,255, filed Dec. 31, 2002, entitled REMAINING TIME PREDICTIONS, U.S. Ser. No. 60/437,224, filed Dec. 31, 2002, entitled DISCHARGE VOLTAGE PREDICTIONS, U.S. Ser. No. 10/349,053, filed Jan. 22, 2003, entitled APPARATUS AND METHOD FOR PROTECTING A BATTERY FROM OVERDISCHARGE, U.S. Ser. No. 10/388,855, filed Mar. 14, 2003, entitled ELECTRONIC BATTERY TESTER WITH BATTERY FAILURE TEMPERATURE DETERMINATION, U.S. Ser. No. 10/396,550, filed Mar. 25, 2003, entitled ELECTRONIC BATTERY TESTER, U.S. Ser. No. 60/467,872, filed May 5, 2003, entitled METHOD FOR DETERMINING BATTERY STATE OF CHARGE, U.S. Ser. No. 60/477,082, filed Jun. 9, 2003, entitled ALTERNATOR TESTER, U.S. Ser. No. 10/460,749, filed Jun. 12, 2003, entitled MODULAR BATTERY TESTER FOR SCAN TOOL, U.S. Ser. No. 10/462,323, filed Jun. 16, 2003, entitled ELECTRONIC BATTERY TESTER HAVING A USER INTERFACE TO CONFIGURE A PRINTER, U.S. Ser. No. 10/601,608, filed Jun. 23, 2003, entitled CABLE FOR ELECTRONIC BATTERY TESTER, U.S. Ser. No. 10/601,432, filed Jun. 23, 2003, entitled BATTERY TESTER CABLE WITH MEMORY; U.S. Ser. No. 60/490,153, filed Jul. 25, 2003, entitled SHUNT CONNECTION TO A PCB FOR AN ENERGY MANAGEMENT SYSTEM EMPLOYED IN AN AUTOMOTIVE VEHICLE, U.S. Ser. No. 10/653,342, filed Sep. 2, 2003, entitled ELECTRONIC BATTERY TESTER CONFIGURED TO PREDICT A LOAD TEST RESULT, U.S. Ser. No. 10/654,098, filed Sep. 3, 2003, entitled BATTERY TEST OUTPUTS ADJUSTED BASED UPON BATTERY TEMPERATURE AND THE STATE OF DISCHARGE OF THE BATTERY, U.S. Ser. No. 10/656,526, filed Sep. 5, 2003, entitled METHOD AND APPARATUS FOR MEASURING A PARAMETER OF A VEHICLE ELECTRICAL SYSTEM, U.S. Ser. No. 10/656,538, filed Sep. 5, 2003, entitled ALTERNATOR TESTER WITH ENCODED OUTPUT, which are incorporated herein in their entirety.

In general, battery maintenance operations such as periodic battery testing and charging may be difficult to carry out in a poorly lit environment, for example, when the battery terminals are recessed in cabinets.

SUMMARY

A battery maintenance tool, which electrically couples to a battery, includes a maintenance tool housing and electronic circuitry within the maintenance tool housing. A cable, substantially external to the maintenance tool housing includes a plurality of conductors. At least some conductors of the plurality conductors are configured to electrically couple to the electronic circuitry within the maintenance tool housing. At least one probe light that is configured to electrically couple to at least two of the plurality of conductors in the cable is also included. The probe light, which is separate from the maintenance tool housing, receives power via the at least two of the plurality of conductors to which it is electrically coupled.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. **1**, **2** and **3** are simplified block diagrams of battery testers in accordance with the present embodiments.

FIGS. **4** and **5** show perspective views of a battery tester Kelvin clamp to which a probe light is coupled in accordance with the present embodiments.

FIGS. **6** through **9** show different embodiments in which probes lights coupled to battery maintenance tool cables receive their power via conductors in the battery maintenance tool cables.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present embodiments, in general, relate to battery maintenance tools (battery testers, battery chargers, etc.) that include probe lights that help illuminate environments in which the battery maintenance tools are used. A battery tester that includes a probe light is a specific example of one of the present embodiments. Such a battery tester is first described below in connection with FIGS. **1** through **4**. Embodiments in which a probe light receives it power through conductors within a battery maintenance tool cable are described further below.

FIG. **1** is a simplified block diagram of electronic battery tester **10**, which includes a probe light **30**, in accordance with one of the present embodiments. The same reference numerals are used in the various figures to represent the same or similar elements. Note that FIG. **1** is a simplified block diagram of a specific type of battery tester. However, the present embodiments are applicable to any type of battery tester including those which do not use dynamic parameters. Other types of example testers include testers that conduct load tests, current based tests, voltage based tests, tests which apply various conditions or observe various performance parameters of a battery, etc. Battery tester **10** includes a test circuit **18**, a memory **20**, an input **68**, an output **22**, cable(s) or probe(s) **14** and probe light **30**. Test circuit **18** includes a microprocessor system **24** and other circuitry, shown in FIG. **3**, configured to measure a dynamic parameter of battery **12**. As used herein, a dynamic parameter is one which is related to a signal having an alternating current (AC) component. The signal can be either applied directly or drawn from battery **12**. Example dynamic parameters include dynamic resistance, conductance, impedance, admittance, etc. This list is not exhaustive, for example, a dynamic parameter can include a component value of an equivalent circuit of battery **12**. Microprocessor system **24** controls the operation of other components within test circuitry **18** and, in turn, carries out different battery testing functions based upon battery testing instructions stored in memory **20**.

In the embodiment shown in FIG. **1**, cable **14** includes a four-point connection known as a Kelvin connection formed by connections **26** and **28**. With such a Kelvin connection, two couplings are provided to the positive and negative terminals of battery **12**. First Kelvin connection **26** includes a first conductor **26**A and a second conductor **26**B, which couple to test circuit **18**. Similarly, first conductor **28**A and second conductor **28**B of second Kelvin connection **28** also couple to test circuit **18**. Employing Kelvin connections **26** and **28** allows one of the electrical connections on each side of battery **12** to carry large amounts of current while the other pair of connections can be used to obtain accurate voltage readings. Note that in other embodiments, instead of employing Kelvin connections **26** and **28**, cable **14** can include a single conductor to couple the first battery terminal to test circuit **18** and a single conductor to couple the second battery terminal to test circuit **18**. Details regarding testing battery **12** with the help of Kelvin connections **26** and **28** are provided further below in connection with FIG. **3**.

As can be seen in FIG. **1**, probe light **30**, which releasably couples to cable **14**, includes a light bulb **32**, a housing **34**, power control circuitry **36** and a switch **40**. Housing **34**, which may be formed of any suitable insulating material (such as plastic), substantially encloses power control circuitry **36**. A lamp holder or socket (not shown), into which light bulb **32** is inserted, is included within housing **34**. Power control circuitry **36** electrically couples to the lamp holder or socket. Probe light-to-cable connector **38**, which is configured to couple probe light **30** to cable **14**, is shown as a single block in the interest of simplification. However, depending upon the type of coupling desired between probe light **30** and cable **14**, probe light-to-cable connector **38** may include one or more components of any suitable design. In some embodiments, probe light **30** releasably mechanically couples to cable **14** and therefore probe light-to-cable connector **38** may include pieces of Velcro (attached to housing **34**, of probe light **30**, and to cable **14**), for example. In some embodiments, instead of Velcro pieces, probe-light-to-cable connector **38** may comprise a double-sided adhesive tape. In other such embodiments, probe-light-to-cable connector **38** may comprise a loop (formed of plastic, for example) that is configured to fit around cable **14**. The loop may be formed integral with housing **34**. In some embodiments, probe light-to-cable connector **38** may comprise a Velcro strap that is attached to housing **34**, of probe light **30**, and configured to wrap around cable **14**. In some embodiments, probe **30** is configured to releasably mechanically and electrically couple to cable **14**. In such embodiments, probe light-to-cable connector **38** may include any suitable male and female plug fittings capable of providing the releasable mechanical and electrical coupling between probe **30** and cable **14**. For simplification, dashed lines **44** and **46** are used in FIG. **1** to denote releasable electrical coupling between power control circuitry **36**, of probe light **30**, and conductors of cable **14**. It should be noted that, although dashed lines **44** and **46** are shown connected to conductors **26**A and **26**B, respectively, electrical coupling between probe **30** and cable **14** can be provided to any suitable combination of conductors **26**A, **26**B, **28**A and **28**B. In some embodiments, power control circuitry **36** includes non-rechargeable batteries (lithium coin cells, AA batteries, AAA batteries, etc.) that provide power to light bulb **32**. In some embodiments, power is supplied to light bulb **32** from test circuitry **18**. For simplification, components such as pull up and/or pull down resistors and other power supply circuitry that may be employed within test circuitry **18** to provide power to probe light **30** are not shown. Light bulb **30** can be switched on and off using switch **40** and/or form a push button (not shown), for example, included in input **68**. In some embodiments, power control circuit circuitry **36** includes rechargeable batteries/capacitors that can be recharged by the battery under test (such as **12**) when it is coupled to tester **10**. Incandescent lamps, cold-cathode lamps, etc., may be employed as light bulb **32**. In some embodiments, probe light **30** has a longitudinal axis **35** that is oriented generally toward an end (such as **106** of FIG. **4**), of one of the first and second Kelvin connections, that couples to one of the first and second terminals of the battery.

FIG. **2** is a simplified block diagram of electronic battery tester **10**, which includes a probe light **30** that couples to probe extension(s) **42** in accordance with one embodiment. Probe extensions **42** are used, for example, when testing batteries employed in Uninterruptible Power Supply (UPS) and telecommunication (telecom) applications. Here, the batteries are in racks with very small clearance between the batteries and very little light, since no light is needed for the batteries to operate. Under such conditions, probe light **30**, mounted on probe extension(s) **42**, helps provide the necessary illumination to ensure that proper selection of battery terminals takes place and proper connection to the selected battery terminals is made by probe extensions **42**, which are used to reach the terminals. In the embodiment shown in FIG. **2**, the coupling of probe light **30**, to probe extension(s) **42**, and the powering and operation of probe light **30** is carried out in a manner similar to that described in connection with FIG. **1** above.

FIG. **3** is a simplified block diagram of electronic battery tester **10** showing components of test circuit **18**. In addition to microprocessor system **24**, test circuit **18** also includes forcing function **50**, differential amplifier **52** and analog-to-digital converter **54**. Amplifier **52** is capacitively coupled to battery **12** through capacitors C_1 and C_2. Amplifier **52** has an output connected to an input of analog-to-digital converter **54** which in turn has an output connected to microprocessor system **24**. Microprocessor system **24** is also capable of receiving an input from input device **68**.

During testing of battery **12**, forcing function **50** is controlled by microprocessor system **24** and provides a current I in the direction shown by the arrow in FIG. **3**. In one embodiment, this is a sine wave, square wave or a pulse. Differential amplifier **52** is connected to terminals **13** and **15** of battery **12** through capacitors C_1 and C_2, respectively, and provides an output related to the voltage potential difference between terminals **13** and **15**. In a preferred embodiment, amplifier **52** has a high input impedance. Tester **10** includes differential amplifier **70** having inverting and noninverting inputs connected to terminals **13** and **15**, respectively. Amplifier **70** is connected to measure the open circuit potential voltage (VBAT) of battery **12** between terminals **13** and **15** and is one example of a dynamic response sensor used to sense the time varying response of the battery **12** to the applied time varying current. The output of amplifier **70** is provided to analog-to-digital converter **54** such that the voltage across terminals **13** and **15** can be measured by microprocessor system **24**. The output of differential amplifier **52** is converted to a digital format and is provided to microprocessor system **24**. Microprocessor system **24** operates at a frequency determined by system clock **58** and in accordance with programmable instructions stored in memory **20**.

Microprocessor system **24** determines the conductance of battery **12** by applying a current pulse I using forcing function **50**. This measurement provides a dynamic parameter related to the battery. Of course, any such dynamic parameter can be measured including resistance, admittance, impedance or their combination along with conductance. Further, any type of time varying signal can be used to obtain the dynamic parameter. The signal can be generated using an active forcing function or using a forcing function which provides a switchable load, for example, coupled to the battery **12**. The processing circuitry determines the change in battery voltage due to the current pulse I using amplifier **52** and analog-to-digital converter **54**. The value of current I generated by forcing function **50** is known and is stored in memory **20**. In one embodiment, current I is obtained by applying a load to battery **12**. Microprocessor system **24** calculates the conductance of battery **12** using the following equation:

$$G_{BAT} = \frac{\Delta I}{\Delta V} \quad \text{Equation 1}$$

where ΔI is the change in current flowing through battery **12** due to forcing function **50** and ΔV is the change in battery voltage due to applied current ΔI. Based upon the battery conductance G_{BAT} and the battery voltage, the battery tester **10** determines the condition of battery **12**. Battery tester **10** is programmed with information which can be used with the determined battery conductance and voltage as taught in the above listed patents to Dr. Champlin and Midtronics, Inc.

The tester can compare the measured CCA (Cold Cranking Amp) with the rated CCA for that particular battery. Additional information relating to the conditions of the battery test (such as battery temperature, time, date, etc.) can be received by microprocessor system **24** from input device **68**. Further, as mentioned above, in some embodiments, probe light **30** can be turned on and off from input **68**.

FIG. **4** shows a perspective view of a battery tester Kelvin clamp **100** to which probe light **30** is coupled in accordance with another embodiment. Kelvin clamp **100** helps couple a Kelvin connection (such as **26**) of cable **14** (not shown in FIG. **4**) to a battery terminal (such as **13** (not shown in FIG. **4**)). As can be seen in FIG. **4**, clamp **100** includes a Plier-Type clip **108** having arms **102** and **104** connected together by pivot **105** and a terminal gripping portion **106** that can be opened or closed with the help of arms **102** and **104**. As in the case of the above-described embodiments, probe light **30** helps provide the necessary illumination to ensure that proper selection of the battery terminal(s) takes place and proper connection to the selected battery terminals is made by Kelvin clamp **100**. For simplification, individual conductors of Kelvin connection **26** are not shown in FIG. **4**. In the embodiment shown in FIG. **4**, the coupling of probe light **30**, to Kelvin clamp **100**, and the powering and operation of probe light **30** is carried out in a manner similar to that described in connection with FIG. **1** above.

FIG. **5** is another perspective view of a battery tester Kelvin clamp **100** with the probe light **30** in a different position than that shown in FIG. **4**. Since the components of the clamps shown in FIG. **4** and FIG. **5** are substantially similar, the same reference numerals are used in both figures. As can be seen in FIG. **5**, probe light **30** is positioned proximate pivot **105** of clamp **100** with bulb **32** positioned such that it automatically points in a same direction as terminal gripping portion **106** of clamp **100**.

As indicated above, a probe light (such as **30**) can be attached to a battery tester cable and, in general, to a battery maintenance tool cable. The description below relates to embodiments in which a probe light (such as **30**) receives it power through conductors within a battery maintenance tool cable.

FIG. **6** is a simplified block diagram of a battery maintenance tool **150**, which includes a probe light **30** that receives power via conductors in the battery maintenance tool cable. Battery maintenance tool **150** includes, as its primary components, a housing **152**, an electronic circuit **154** (which can include battery charging circuitry and/or battery testing circuitry, etc.), cable **14**, probe light **30** and a probe light power supply **156**.

As can be seen in FIG. **6**, cable **14**, which is substantially external to battery maintenance tool housing **152**, includes a plurality of conductors **26**A, **26**B, **28**A, **28**B, **158** and **160**. Conductors **158** and **160** are optional. At least some conductors of the plurality of conductors (**26**A, **26**B, **28**A, **28**B, **158** and **160**) are electrically coupled to electronic circuitry **154** within housing **152**. Further, probe light **30** electrically couples to at least two of the plurality of conductors in cable **14**. For simplification, the electrical coupling of at least two of the plurality of conductors (**26**A, **26**B, **28**A, **28**B, **158** and **160**) to probe light **30** is shown by dashed lines **44** and **46**. As noted above, probe light **30**, which is separate from battery maintenance tool housing **152**, receives power via the at least two of the plurality of conductors (**26**A, **26**B, **28**A, **28**B, **158** and **160**) to which it is electrically coupled.

As in the case of the earlier-described embodiment shown in FIG. **1**, cable **14** of FIG. **6** includes a four-point Kelvin connection formed by connections **26** and **28**. First Kelvin connection **26** includes first conductor **26**A and second conductor **26**B that couple to electronic circuit **154**. First conductor **28**A and second conductor **28**B, included in second Kelvin connection **28**, also couple to electronic circuit **154**. Additionally, in some embodiments, at least some of Kelvin conductors **26**A, **26**B, **26**C and **26**D are electrically coupled to probe light **30** and electrically coupled to probe light power supply circuitry **156**. In such embodiments, Kelvin connections **26**, **28** serve a dual purpose of electrically coupling electronic circuitry **154** to battery **12** and operating as power supply conductors for probe light **30**. As indicated above, in some embodiments, one or more additional conductors such as **158** and **160** are included in cable **14**. Here, one or both of conductors **158** and **160** can be used along with, or instead of, at least one of Kelvin conductors **26**A, **26**B, **26**C and **26**D to supply power to probe light **30** from probe light power supply **156**. In general, the embodiments described in connection with FIG. **6** eliminate any need for batteries within probe light housing **34** to power light bulb(s) or lamp(s) **32**.

FIG. **7** shows a specific embodiment of a probe light **30** that receives its power from conductors within cable **14**. In FIG. **7**, a current limited power supply **156** is connected to conductors of Kelvin Connections such as **26** and **28**, and a probe light **30** is placed across those conductors proximate to ends of the Kelvin connections that connect to terminals of battery **12**. Probe light **30** may include a light-emitting diode (LED) **162** and a reverse protection diode **164** for the LED **162**. Instead of an LED (such as **162**), an incandescent lamp can be used in some embodiments. In embodiments that use an incandescent lamp, no protection diode such as **164** is necessary. In general, any suitable lamp can be used for probe light **30**.

In the embodiment shown in FIG. **7**, when probe light power supply **156** is ON, a lamp such as **162** is always ON until Kelvin probes **26** and/or **28** contact the battery posts. However, when there is proper contact between the Kelvin connections **26** and **28** and the battery terminals, the light is not needed. Thus, this feature provides visual feedback that a "good" connection has been made.

FIG. **8** shows another embodiment that illustrates how power can be supplied to probe light **30** via conductors of a Kelvin connection. In this embodiment, an alternating current (AC) power source **156** is used to supply power to lamp **32** of probe light **30**. In the circuit of FIG. **8**, capacitors **166** and **168** are employed to block the flow of direct current (DC). When probe light power supply **156** is ON, and conductors **26**A and **26**B held electrically separate (or isolated) from each other when Kelvin clamp **100** is in an open position or when any other suitable conductor separation mechanism **170** (for example, two insulated conductors in Kelvin probe **26**) is used, lamp **32** remains ON. However, when conductors **26**A and **26**B are electrically coupled to the battery terminal as shown in FIG. **8**, lamp **32** turns OFF due to the absence of a voltage across the lamp. In the embodiment shown in FIG. **8**, it is also possible for microprocessor system **24** to monitor, or periodically measure, AC current I_1 by measuring a voltage across resistor **172** and, based on the value of measured current, determine whether to turn probe light power supply **156** ON/OFF.

FIG. **9** is a block diagram of an embodiment that utilizes multiple LEDs/lamps (**174**, **176**) of different colors. For example, a white light can be used for illumination before a proper connection is made between the Kelvin connection(s) and the battery terminal(s). When a proper connection is made between the Kelvin connection(s) and the battery post(s), the white light can be turned OFF and a green light turned ON. In one example embodiment, microprocessor system **24** can detect whether the Kelvin connections are properly connected to the battery terminals and accordingly turn ON/OFF the appropriate lamp.

Although the present embodiments have been described with reference to preferred embodiments, workers skilled in the art will recognize that changes may be made in form and detail without departing from the spirit and scope of the disclosure.

What is claimed is:

1. A battery maintenance tool comprising:

a maintenance tool housing;

electronic circuitry within the maintenance tool housing;

a cable, substantially external to the maintenance tool housing, comprising a plurality of conductors, wherein at least some conductors of the plurality conductors are configured to electrically couple to the electronic circuitry within the maintenance tool housing;

at least one probe light, separate from, and independent of, the maintenance tool housing, the at least one probe light configured to electrically couple to at least two of the plurality of conductors in the cable,

wherein the at least one probe light is configured to receive power via the at least two of the plurality of conductors to which it is electrically coupled.

2. The battery maintenance tool of claim **1** wherein the cable comprises:

a first Kelvin connection, which includes a first set of two conductors of the plurality conductors in the cable, configured to electrically couple to a first terminal of a battery; and

a second Kelvin connection, which includes a second set of two conductors of the plurality of conductors in the cable, configured to electrically couple to a second terminal of the battery.

3. The battery maintenance tool of claim **2** wherein the at least two conductors of the plurality of conductors to which the probe light is electrically coupled are separate from, and additional to, the first Kelvin connection and the second Kelvin connection.

4. The battery maintenance tool of claim **2** wherein at least one of the at least two conductors of the plurality of conductors to which the probe light is electrically coupled is a conductor included in one of the first Kelvin connection and the second Kelvin connection.

5. The battery maintenance tool of claim **2** wherein the at least two conductors of the plurality of conductors to which the probe light is electrically coupled are conductors included in at least one of the first Kelvin connection and the second Kelvin connection.

6. The battery maintenance tool of claim **2** wherein the at least two conductors of the plurality of conductors to which the probe light is electrically coupled are one of the first set of two conductors included in the first Kelvin connection and the second set of two conductors included in the second Kelvin connection and wherein the at least one probe light turns off when proper contact is made between the respective one of the first Kelvin connection and the first battery terminal and the second Kelvin connection and the second battery terminal to which the probe light is connected.

7. The battery maintenance tool of claim **2** wherein the at least one probe light turns off when proper contact is made between at least one of the first Kelvin connection and the first battery terminal and the second Kelvin connection and the second battery terminal.

8. The battery maintenance tool of claim **2** wherein the at least one probe light changes color when proper contact is made between at least one of one of the first Kelvin connection and the first battery terminal and the second Kelvin connection and the second battery terminal.

9. The battery maintenance tool of claim **1** wherein the at least one probe light comprises a light-emitting diode.

10. The battery maintenance tool of claim **1** wherein the at least one probe light comprises an incandescent lamp.

11. The battery maintenance tool of claim **1** wherein the electronic circuitry comprises battery testing circuitry.

12. The battery maintenance tool of claim **1** wherein the electronic circuitry comprises battery charging circuitry.

13. A method comprising:

coupling at least one probe light to at least two of a plurality of conductors of a battery maintenance tool cable; and

powering the probe light through the at least two of the plurality of conductors of the battery maintenance tool cable.

14. The method of claim **13** wherein the at least two of the plurality of conductors of the battery maintenance tool cable are part of at least one of a first Kelvin connection and a second Kelvin connection of the battery maintenance tool cable.

15. The method of claim **13** wherein the at least two of the plurality of conductors of the battery maintenance tool cable are separate from, and additional to, a first Kelvin connection and a second Kelvin connection of the battery maintenance tool cable.

16. The method of claim **14** and further comprising turning off the al least one probe light when proper contact is made between one of the first Kelvin connection and a first battery terminal and the second Kelvin connection and a second battery terminal.

17. The method of claim **14** and further comprising turning off the al least one probe light when proper contact is made between the first Kelvin connection and a first battery terminal and the second Kelvin connection and a second battery terminal.

18. The method of claim **14** and further comprising changing a color of the al least one probe light when proper contact is made between one of the first Kelvin connection and a first battery terminal and the second Kelvin connection and a second battery terminal.

19. The method of claim **14** and further comprising changing a color of the al least one probe light when proper contact is made between the first Kelvin connection and a first battery terminal and the second Kelvin connection and a second battery terminal.

20. The method of claim **13** wherein coupling at least one probe light to at least two of a plurality of conductors of a battery maintenance tool cable comprises coupling one of a light-emitting diode and an incandescent lamp to the at least two of the plurality of conductors of the battery maintenance tool cable.

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